APPENDIX 13 – Hydrology and Hydrogeology Baseline

Hydrology & Hydrogeology

The selected area is located under the following coordinate system: 41°36'41.59" N, 64°27'23.95" E and following map (fig.1&2) describes the geographical location.

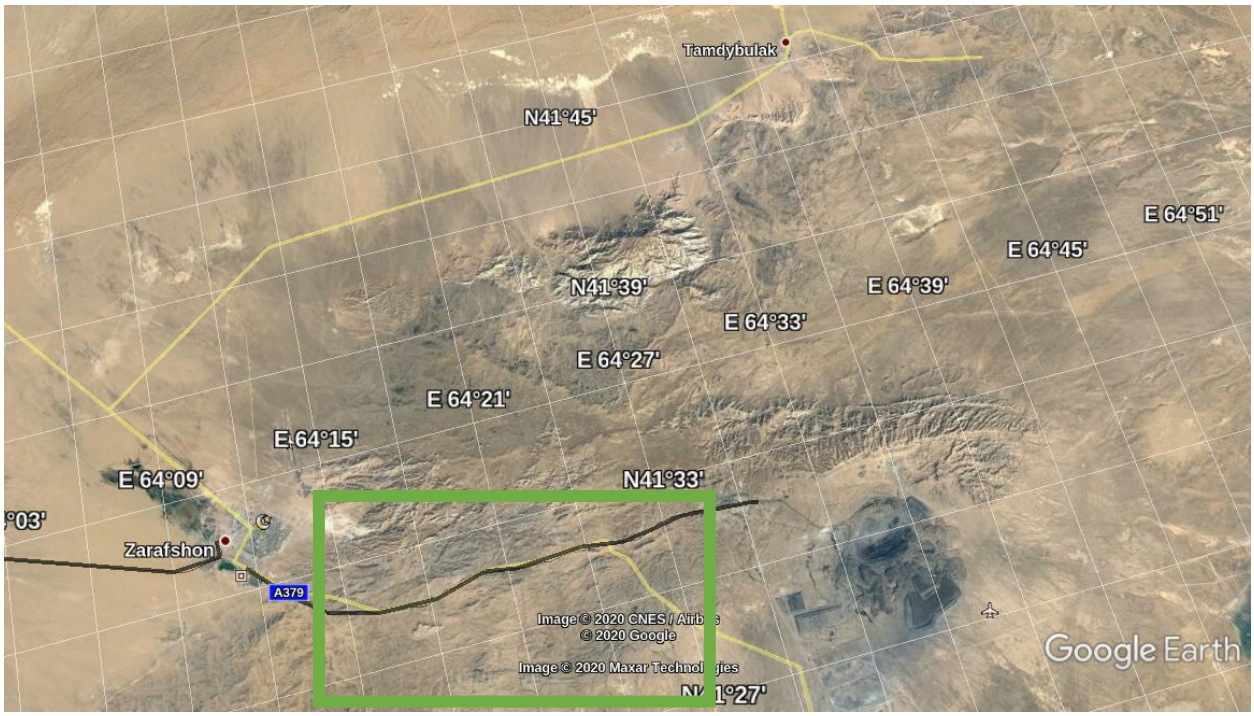


Figure 1. The selected rectangle described the wind turbine area for estimation place and location.

The selected region is Tamdy. Tamdy is located northern side of Uzbekistan and administrative zone of Navoi region. Tamdynsky (Tamdy) district occupies the northeastern and partly central part of the Navoi region. From the north and east it borders on Kazakhstan, in the west - with Uchkuduk, in the south-west - with Kanimekh, in the southeast across Lake Aydarkul - with Nurata district of Navoi region, in the extreme southeast - with Jizzakh region. The area of the district is 42.4 thousand km^2, and with this indicator Tamdynsky district is in second place in terms of area among the districts of the Navoi region (in the first place is the Uchkuduk district with an area of 46.6 thousand km^2). Almost the entire part of the region's territory is covered by deserts and steppes. The central part of the Kyzylkum desert is located in this district area (Tamdy).

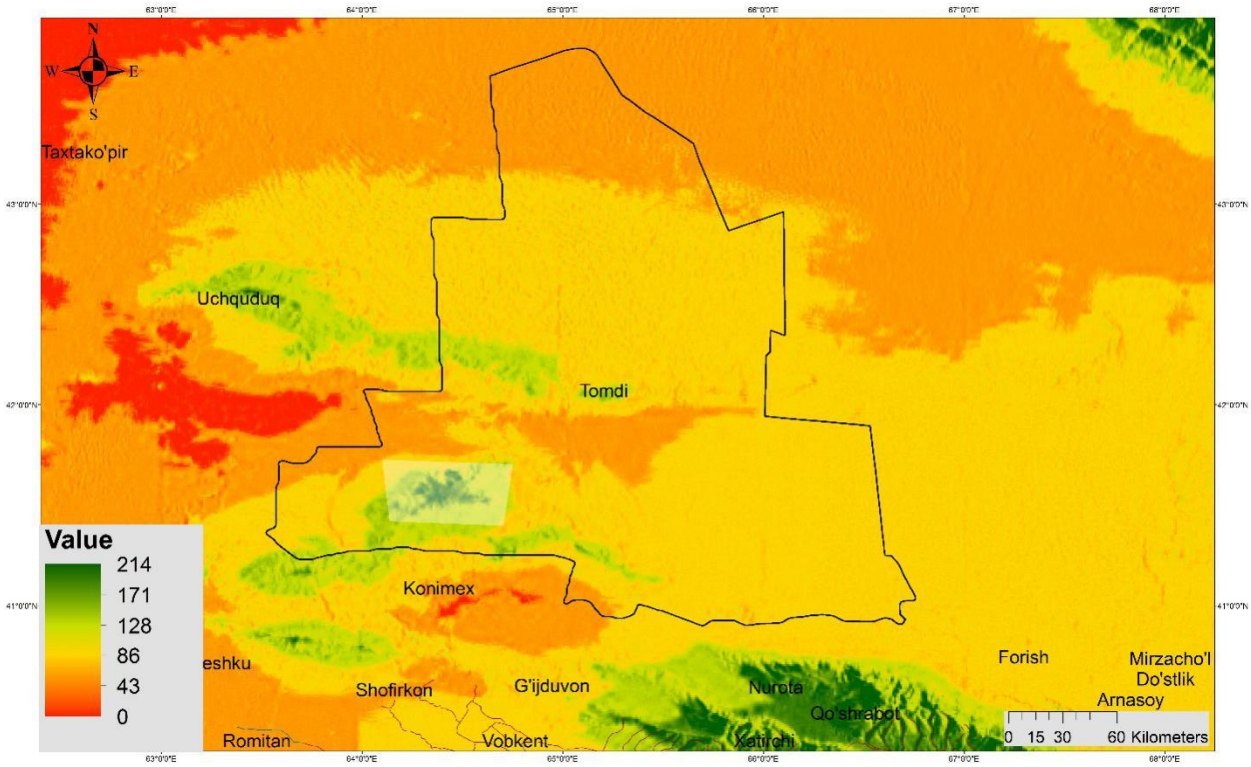


Figure 2. Digital elevation models (DEMs) from USGS series are arrays of elevation value for referenced area, the projection based on Universal Transverse Mercator (UTM) projection.

Administratively, the district is located on the territory of the Tamdy district of the Navoi region (the settlements of Kulumbet, Aldabergan, Ugiz (Kerigetau), Jrik, Uriskuduk and Utemurat). Large settlements - the city of Zarafshan, the city of Uchkuduk, the regional center of Tamdy and other settlements, are located at the foot of the mountain ranges, where there are wells and springs with fresh and slightly saline water. The region's elevation is varied from 100 m a.s.l and target area where will be installed wind turbines pointed as the high point of the area and elevation varies from 180 till 215 m a.s.l.(fig.2.). The described area is confined to the East-Kyzylkum artesian basin and the surrounding mountains. The conditions for feeding, accumulation, movement, consumption and distribution of groundwater in the study area are determined by the geological, tectonic, geomorphological structure of the surface relief.

Water sources in the area

The major river's delta like Amudarya and Syrdarya are far away from the selected region, only available non-perennial water sources which is accumulated from spring sources (rain,snow). The distance of the major attributary of the Syrdarya river approximately 365.97 km from north side (calculated from Kyzylorda region, Kazakhstan until target area), from east side nearly from South Kazakhstan region, Kazakhstan distance reached around 317.77 km. From Aydarkul Lake (east-southern side) distances 150 km.

The Amudarya river from targeted area until Lebap region, Turkmenistan the distance appr. around 308.87 km (south side), from western side where borders reached Khoresm area, Uzbekistan (pic.1) the distance is around 228.40 km (pic1)

Picture 1. Attributaries of Amudarya river in the territory of Khoresm and Karakalpaksan area. Coordinates: E61^{0}30′; N42^{0}06′ [1]

As described in the map(fig.3)the northern east side located perennial water sources. In the selected area (hereafter: wind turbine area) there is no sources related to the springs

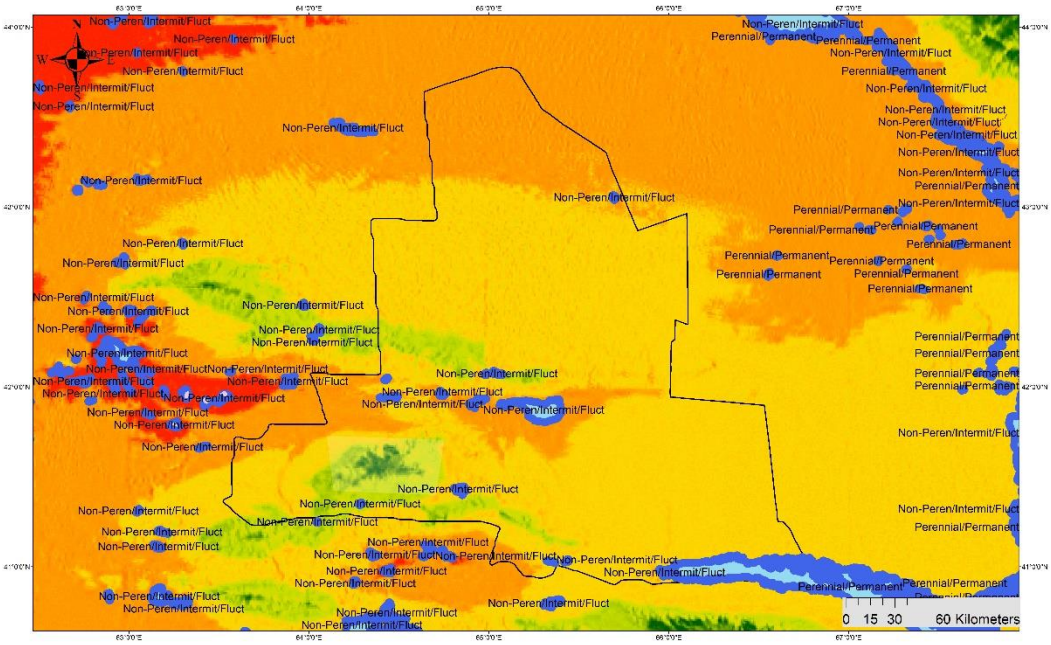


Figure 3. Geographic map of the water sources and their distributions in the target area.

The general physical and geographical characteristics of the selected area: there are no conditions for the formation of permanent surface watercourses. But within the limits of mountain heights and foothill plains, a network of valleys of temporary streams is widely developed, acting only in the spring period as well as, during heavy rain seasons and intense snow melting. Such streams operate for a short time period and form of or categorized as temporary reservoirs.

[1] https://lh5.googleusercontent.com/p/AF1QipPoUvj35ptLGQu-UWdu2twK51U6_tGJupdcKMyH=h720

Water Sources / Quality

The source has prepared on the base of HydroIngeo Institute's report and their activities related on previous expedition on this area. Originally, the report translated from Russian to English.

In order to establish the existing sources of drinking water supply to 6 rural settlements of *Kulumbet, Aldabergan, Ugiz (Kerigetau), Jrik, Uriskuduk* and *Utemurat* of the Tamdy district of Navoi region, a survey of existing production wells and water intakes was carried out, the conditions and regime of water supply to 6 rural settlements located on the area works. These 6 settlements located in the south-eastern side of the Tamdy region, and appr. distance from targeted area varies from 50-100 km.

During the survey of the territories, sources of potable water supply to settlements and watering of pastures were identified, the location of production wells and water intakes was clarified, the available geological and technical documentation was collected, the technical condition of ground water lifting equipment was described, the level and flow rates of water in wells were measured and water samples were taken for chemical analyzes.
Within the work area there are 6 rural settlements with a total number of 3169 people. The need for potable water is **366 m^3/day** or **4.31L per second**.

Tamdy district

The major settlements in the Tamdy district, Navoi area mostly located at the foot of the mountain ranges. Due to availabilty of the springs and wells near mountain zones. These 6 settlements are located southeastern part of the Tamdy district

1. Settlement "Kulumbet"
The settlement "Kulumbet" is located in the southeastern part of the Tamdy district. 720 inhabitants live in the village, with a water consumption rate in rural areas of 115 l / day (or 0.115 m3 / day), the need for domestic drinking water is 83 m3 / day or 1.0 l / s, if we consider that the pump will only work during the day day (10 hours), then the need will be 2.3 l / s. Household and drinking water supply of the settlement and watering place for livestock is carried out at the expense of 4 wells. Submersible pumps of Chinese production are installed to the wells, with an average flow rate of 1.0 l / s, while the total daily withdrawal is 15-20 m3 / day. The depth of the wells is 35.0-40.0 m, the static level of groundwater was established at a depth of 24-26 m. The quality of groundwater is salty, the mineralization of water is 1.2-1.5 g / l, the total hardness is 14-18 mg-eq / l, which does not correspond to O'zDSt[2] 950: 2011 "Drinking water" and the problem of water supply has not been resolved.

2. Settlement "Aldabergan"
The settlement "Aldabergan" is located in the southeastern part of the Tamdy region. There are 389 inhabitants in the settlement, the need for domestic drinking water is 45 m3 / day or 0.52 l / s, if we take into account that the pump will operate only during the daytime (10 hours), then the need will be 1.25 l / s. Household and drinking water supply of the settlement is carried out at the expense of imported water from the village of Ayakkuduk, located 50 km to the west. In addition, there are 3

[2] O' zDSt 950: 2011 "Drinking water"- Standartization rules of the Republic of Uzbekistan

wells for livestock watering in the village, of which 2 wells work for 2-3 hours a day. Belt pumps are installed to the wells, with an average flow rate of 1.0 l / s, the daily withdrawal is 14-15 m3 / day. The depth of the wells is 37.6-42.0 m, the static level of groundwater is 37-38 m. In terms of quality, groundwater is salty, water salinity is 1.2-1.4 g / l, total hardness is 18-21 mg-eq / l, which does not correspond to O'zDSt 950: 2011 "Drinking water".

3. Settlement "Ugiz" (Kergitau)

The settlement "Uguz" is located in the southeastern part of the Tamdynsky district. The village has 560 inhabitants. The need for domestic drinking water is 65 m3 / day or 0.75 l / s, if we take into account that the pump will work only during the daytime (10 hours), then the need will be 1.8 l / s.
Household and drinking water supply of the settlement is carried out at the expense of a single production well. The well is cased with 168mm pipes. The depth of the well, according to the local population, is 80-100m, a submersible pump of the ETsV4-4-80 brand has been installed, it works from 3 to 8 hours a day, the withdrawal of groundwater is 15-20 m3 / day. Imported water is delivered to the population by tank trucks. The quality of the groundwater is brackish, the mineralization of the water is 1.6 g / l, the total hardness is 6-7 mg-eq / l, which does not correspond to O' zDSt 950: 2011 "Drinking water".
In addition, in the northern, north-eastern and southern parts of the village there are wells that provide watering for livestock and irrigate gardens. The quality of the groundwater is brackish, the salinity of the water is 1.7-2.5 g / l, the total hardness is 11.5-14.0 mg-eq / l, which does not correspond to O' zDSt 950: 2011 "Drinking water".

4. Settlement "Jirik"

The settlement "Jirik" is located in the southeastern part of the Tamdy region. 380 inhabitants live in the settlement, the need for domestic drinking water is 44 m3 / day or 0.51 l / s, if we take into account that the pump will work only during the daytime (10 hours), then the need will be 1.22 l / s.
Household and drinking water supply of the settlement is carried out at the expense of imported water from the settlement of Uguz. There are single wells for livestock watering in the village. The quality of groundwater is salty, the mineralization of water is 2.7-3.0 g / l, the total hardness is 17.7 mg-eq / l, which does not correspond to O' zDSt 950: 2011 "Drinking water".
To solve the domestic and drinking water supply of the village of Jirik, due to the lack of fresh groundwater at the site and the small need, it is recommended to supply water from the village of Ugiz.

5. Settlement "Utemurat"

The settlement "Utemurat" is located in the southeastern part of the Tamdy district. There are 1000 inhabitants in the village, the need for domestic drinking water is 115 m3 / day or 1.33 l / s, if we take into account that the pump will work only during the daytime (10 hours), then the need will be 3.2 l / s.
Domestic and drinking water supply of the settlement is carried out at the expense of the imported water from the settlement of Tomdy, by tank trucks. There are 3 production wells for watering in the village, which are currently not working, the wells are forgotten. One well located in the eastern part is being operated, the depth of the well is 100 m, a deep-well pump ЭЦВ6-10-80 is installed in it. The quality of underground waters is salty, the mineralization of water is more than 1.5 g / l, it is used for watering livestock.

6. Settlement "Uriskuduk"
The settlement "Uriskuduk-Urtakuduk" is located in the southeastern part of the Tamdy district. There are 120 inhabitants in the village, the need for domestic drinking water is 14 m3 / day or 0.2 l / s, if we take into account that the pump will work only during the daytime (10 hours), then the need will be 0.4 l / s. Household and drinking water supply of the settlement is carried out at the expense of imported water from the settlements of Tomdy and Keriz, by tank trucks. There are 3 wells for livestock watering in the village. The wells are equipped with belt pumps, brand ЗИД-50. The pumps operate for 1-2 hours a day, groundwater withdrawal is 8-12 m3 / day. The quality of the underground waters is salty, the mineralization of the water is more than 3.1 g / l, the total hardness is 13.6 mg-eq / l. The depth of the wells is 50-55 m and is currently in emergency condition.When sands were tested in the range of 65.35-74.35 m, water was obtained with a flow rate of 2.0 l /second, with a decrease in the level by 2.34 m, the specific flow rate was 0.85 l / s, the static level was established at a depth of 42.51 m. The quality of the groundwater is fresh, the dry residue is 0.4 g/l, the total hardness is 5.50 mg-eq/l, the composition is chloride-sulphate-calcium-magnesium water.

Zarafshan city

1. Rohat ovuli (settlement)
The settlement " Rohat ovuli" is located in the southwestern part of the Zarafshan district. It is typical village with 1050 inhabitants. There is no sources of tap water and natural gas.The water sources extended from Amudarya River Basin and inhabitants consuming technical (unfiltered) water for everyday needs.The direction is western side from target area.
The distance of the settlement from target area around 16-25km.

Muruntau gold mining factory

1. Muruntau district
This small area especially constructed for Muruntau employee. There is no private houses and lives only Muruntau employee.Due to extension of the industrial sector in the mining lines, it might be this district will extended (movement) to the Zarafshan city.The direction is south-eastern side.
The distance of the settlement from target area around 20 km.

Mountain area of the Tomdy district (settlements)

1. New Tamdy
In this area inhabitants around 692 people. It is central part of the area, municipiality moved in 2008 from Old Tomdy area. The area have established all natural resources like natural gas, tap water,etc. The distance of the settlement from target area around 15km.

2. Ajrikti

Based on location it has established between old and new Tamdy area. Inhabitants 810 people. Available tap water and lightning. Inhabitants privately digging wells for consuming technical water for less using tap water. The distance of the settlement from target area around 20 km

3. Tamdybulak (Old Tamdy)
Previously, it was central part of the area. During 1996-2008 periods, inhabitants step by step moved to the New tamdy based on requirements of the Ministry Disaster Prevention in Uzbekistan.The area is seismic zone, and geomorphology of the soil structure is bentonit silt and available zig zag line (hole) which is sensible to the earthquake. Inhabitants 2580 people. Currently, all natural resources are available in this area, exceptionally for natural gas. The distance of the settlement from target area around 25 km

4. Qinir
Based on location is far from New Tamdy (27 km) and from Old Tomdy around 17 km. The natural resources are not available in this area. Inhabitants paid for water which transported from Old Tamdy. This zone is famous with camel husbandry. Inhabitants 23 people and 6 farming established there. The distance of the settlement from target area around 35-40 km.

5. Jinghildy
This settlement is far zone. Compare to the Old Tamdy is located 60 km. Inhabitants are 25-30 people, 7 farming area is located there. There is a water reservoir is around 5km, near on this settlement (appr.5km) The distance of the settlement from target area around 50km (the farest one).

Current Sources of Pollution

The current sources of pollution are not available for this region. Based on oral communication with rural areas that indicate to the air polllution of the area and big area near to the Muruntau gold mining zone accumulated with technic water (polluted water which has used on technical needs), trash water has extended year by year and majority of water evaporated openly in the atmosphere and might be filtering to the groundwater

Water consumption (wells, water sources): drainage water, superficial ground water, deep ground water; permits required for use of water

The water content varies from 100 until 1.7 l / s. Groundwater is practically not used in this area. The general direction is from south - east to north - west towards the Mulala depression. Water abundance is determined by specific flow rates from 1.1 to 2.7 l / s (central part) and from 0.02 to 0.5 l / s (in the south-west), salinity from 0.5 to 1.0 g / l (central part), 1-3 g / l (northern and south - western part), and near Mulala up to 6-7 g / l. The complex is operated by numerous wells:

- a) the aquiferous complex of Quaternary sediments (Q) is widespread and coincides with the distribution, spreads only in the places where more ancient formations emerge on the surface. The water-bearing rocks are aeolian sands.
- Impervious sediments between the Quaternary aquifer and the underlying Upper Pliocene do not exist.

- b) the aquiferous complex of the Upper Pliocene sediments (N23) - depending on the water-bearing ones, and the following are distinguished:
- Complex of alluvial deposits (aN23), which extend in a strip 30–45 km wide from south - west to north - east. The water-bearing rocks are alluvial gray sands and weak-strength sandstones with interlayers of clays, the total thickness is up to 70 m.This complex is characterized by an increase in mineralization with a depth of 0.5 - 0.7 g / l (the upper part of the section), to 1.7 and more g / l (lower part). The water content varies in the range from 1 to 1.4 l / s, the composition of water from hydrocarbonate to sulfate - sodium chloride. Groundwater is practically not used.
- Akchagyl stage of the Upper Pliocene (akN23) - this aquiferous complex is widespread, absent only near mountain uplifts. The water-bearing rocks are sandstones with interlayers of siltstones and gypsites. The thickness increases from the periphery to the center, where it is 145 - 150 m. This complex is underlain by a water-resistant clayey stratum of the Agitma Formation. Mineralization varies from 1.6 to 17.6 g / l, according to the composition of the water sulfate-chloride sodium and potassium.
- an aquifer of the Senonian and Paleocene sediments (K2sr-p1).
- This complex is widespread, except for areas of outcropping of Paleozoic rocks. This aquiferous complex lies on the water-resistant clays and siltstones of the Turonian. The greatest depth of the aquifer level is observed in the Ergashkuduk trough, where it reaches 851 m.
- Water-bearing rocks - sands, sandstones, conglomerates and siltstones with thin clay interlayers. The rocks contain mainly confined waters, and with an increase in the depth of the complex, the levels of groundwater also increase accordingly.
- In the central part of the Ergashkuduk trough, they reach 840 m, in the southwestern wing of the trough, the head is 237 m, in the Mulalin depression - 133 m, in the foothills of Aristantau - 73 m.
- Water content is different, well flow rates vary widely and range from 0.002 to 31.8 l / s. Mineralization varies from 1 to 3 g / l or more, according to the composition of water, mainly sodium sulfate type II.
- The aquifer is fed mainly outside the field, where these deposits are exposed over a large area, due to the inflow through the fracture zones, as well as local runoff from the Aristantau and Sangruntau mountains. Unloading is carried out in the closed-drain Mulaly depression along the faults that cut the foundation and cover, as well as due to overflow into the overlying complexes. Groundwater is widely used for drinking and industrial water supply.

  In rural areas potable water needs for settlements Kulumbet, Aldabergan, Ugiz, Jirik, Uriskuduk, Utemurad (target zone: Tamdy district, Navoi region)

№	Settlements	Inhabitants	Water consumption per day, m³/day L/second	Household drinking water deficit m3/day L/second	Comment
1	Kulumbet	720	83,0/1,0	83,0/1,0	Available 4 wells and one artesian water скв№1р
2	Aldabergan	389	45/0,52	45/0,52	Available 3 wells and water transported from near village Ayakkuduk
3	Ugiz	560	65/0,75	65/0,75	Available 3 wells and prospecting and shallow-pool test of 4пр[3]
4	Jirik	380	44/0,51	44/0,51	Available 3 wells and water transported from near village Uguz
5	Utemurat	1000	115/1,33	115/1,33	Water transported from Tamdy center and prospecting and shallow-pool test 10пр and due to availabity 3 wells
6	Uriskuduk	120	14/0,2	14/0,2	Available 3 wells and water transported from Tamdy and Keriz
	Total	**3169**	**366 /4,31**	**366/4,31**	

Rainfall

The weather data (Tamdy region) estimated from 1990 until 2019 and based on monthly observations. The average total sum of rainfall is varying from 100-111 mm per year. And mostly rainfall period is March and April month, while summer (June, July and August) months mostly no rain period.

[3] Пр-the number of artesian wells

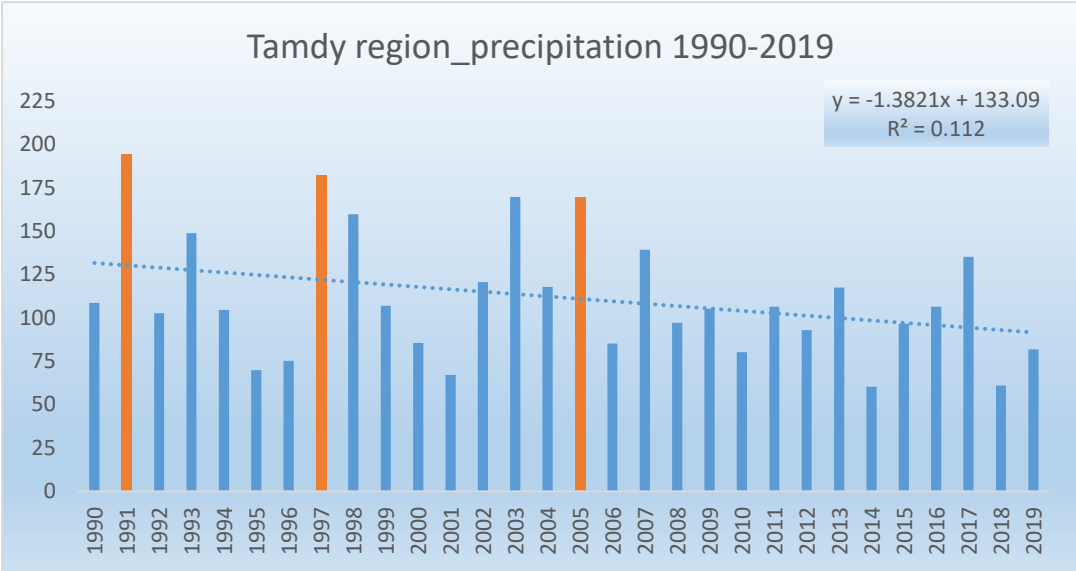


Figure 4. The total sum of rainfall estimated in the selected region from 1990 till 2019. The red color described intensified rainfall year (*194.3 mm/year in 1991, 182.6 mm/year in 1997, and 169.8 mm/year in 2005*). The linear trend for rainfall is getting down which means that rainfall ratings is getting low in this area.

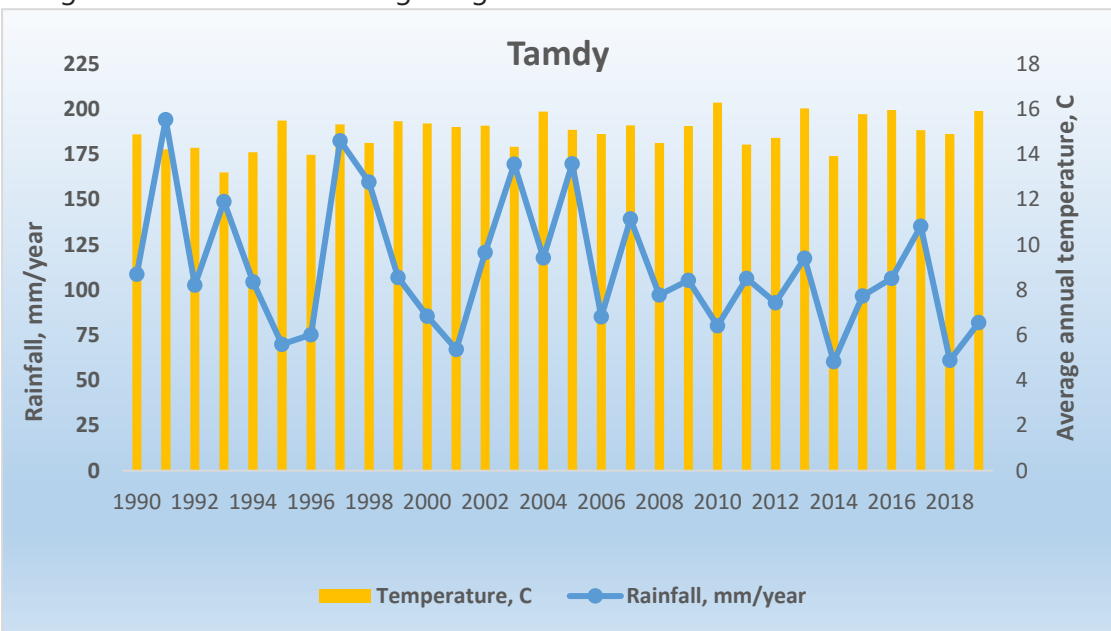


Figure 5. Comparing average annual temperature and average annual sum of rainfall for selected region in the period 1990-2019.

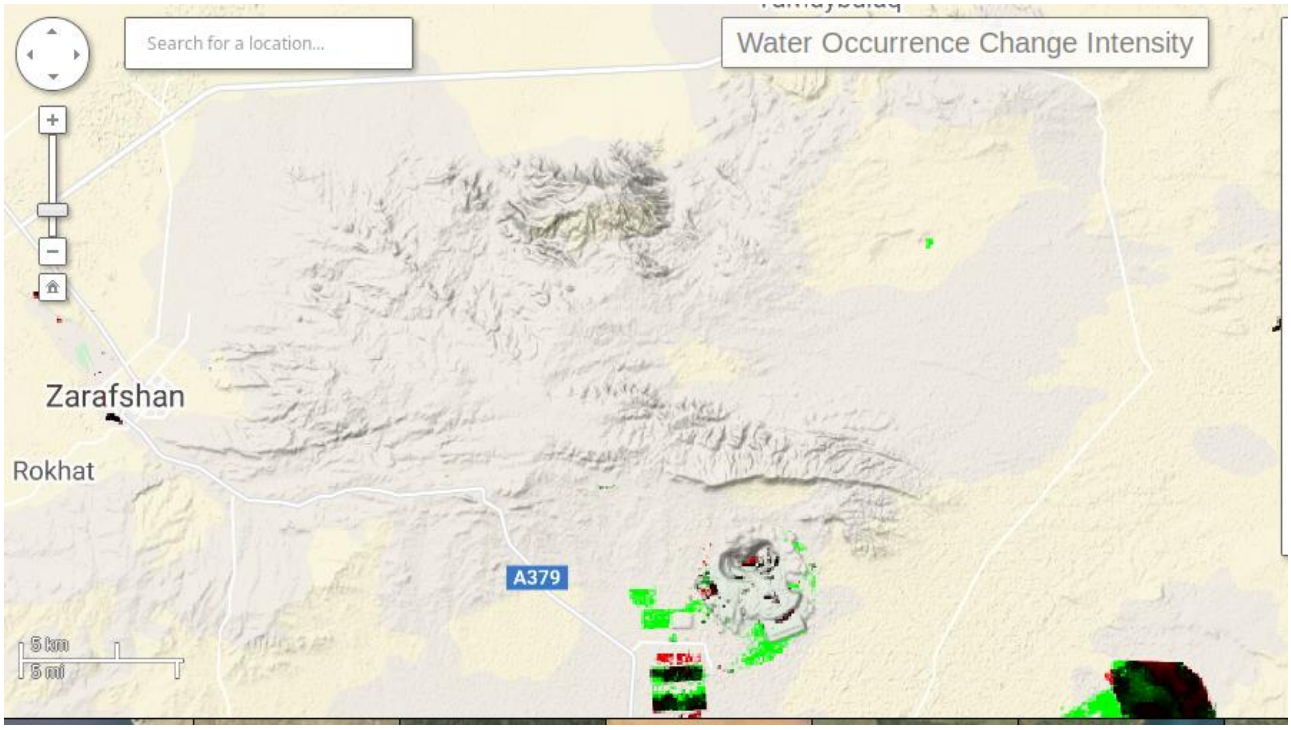
Groundwater and quality

The described area is confined to the East Kyzylkum artesian basin and the surrounding mountain ranges. The conditions for feeding, accumulation, movement, consumption and distribution of groundwater in the study area are determined by the geological, tectonic, geomorphological structure of the surface relief.

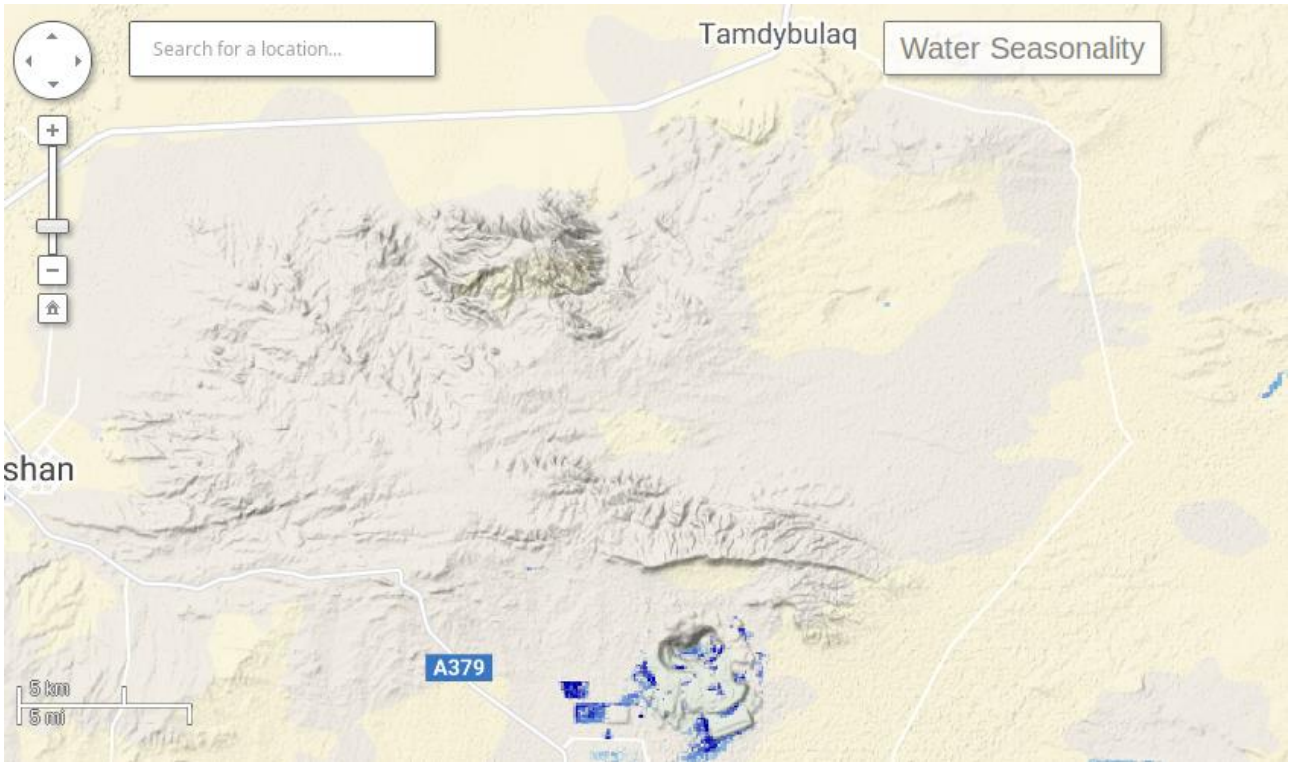
According to the study areas, the following aquifers are distinguished:

- aquifer complex of Quaternary deposits;
- aquifer of the Upper Pliocene sediments;
- aquifer of the Lower Pliocene deposits;
- an aquifer of Senonian and Paleocene sediments.

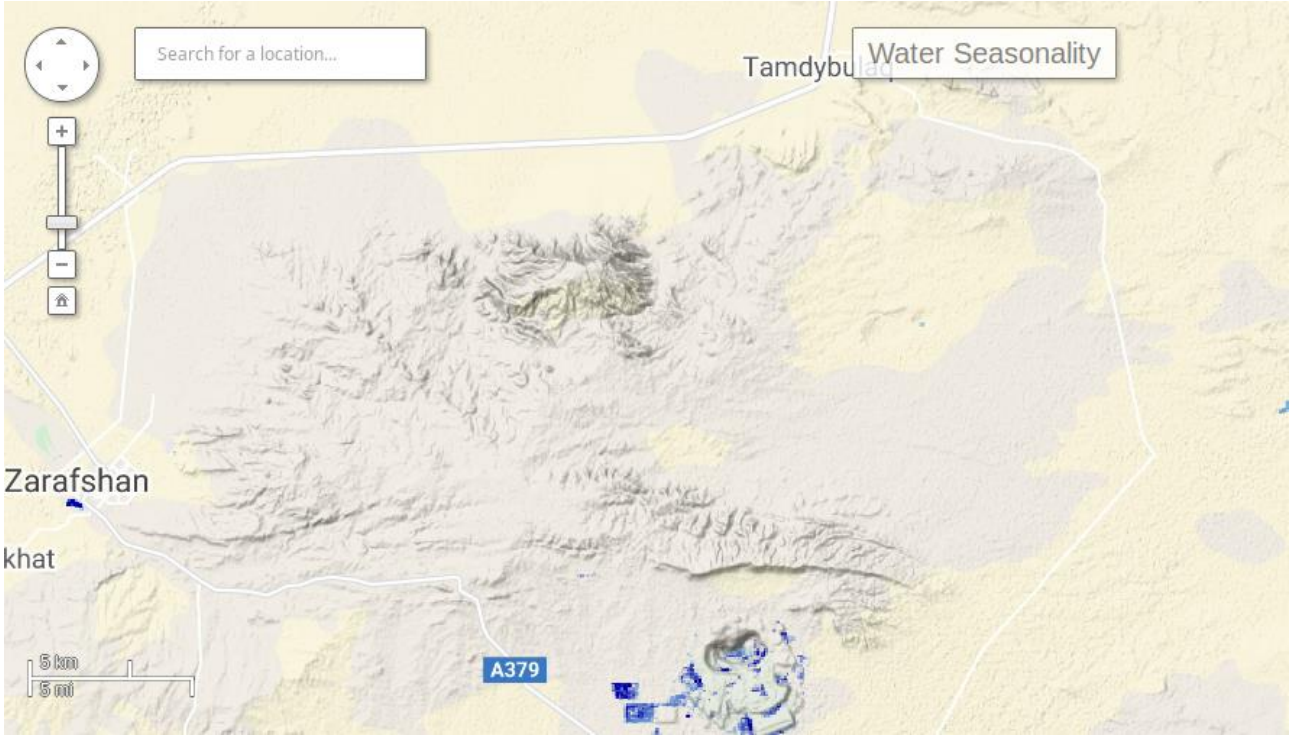
The selected regions hydrological exploration has done by using Google Earth Engine Tool

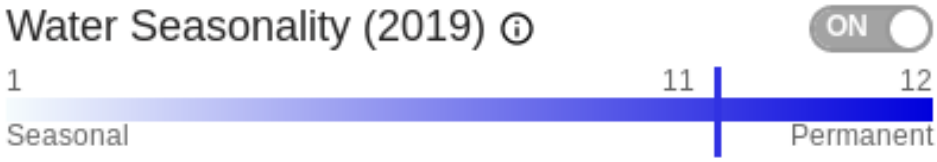


Water seasonality



Water seasonality





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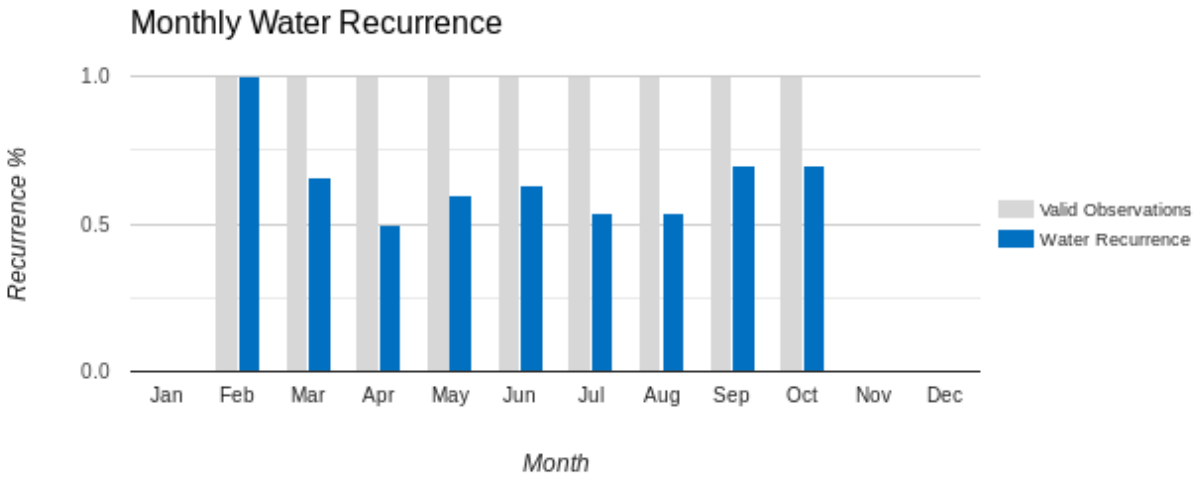
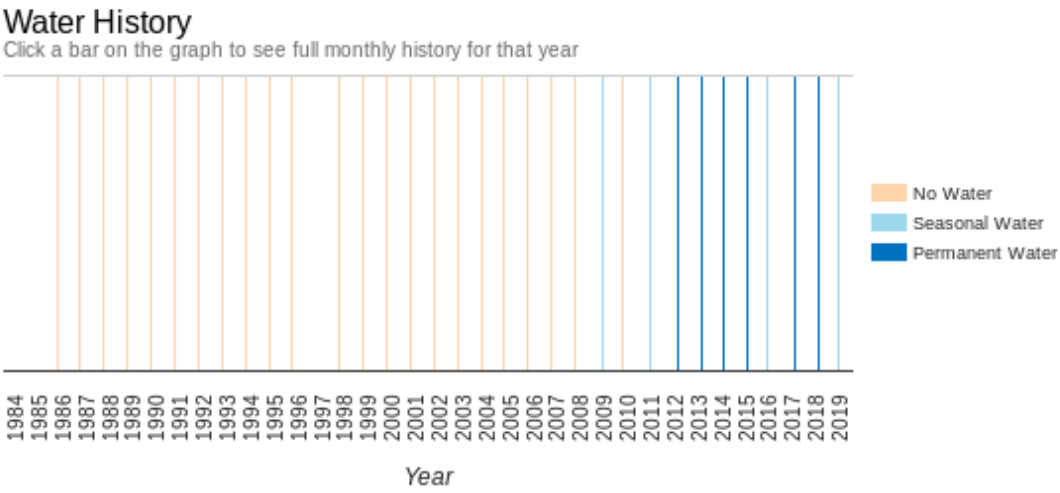
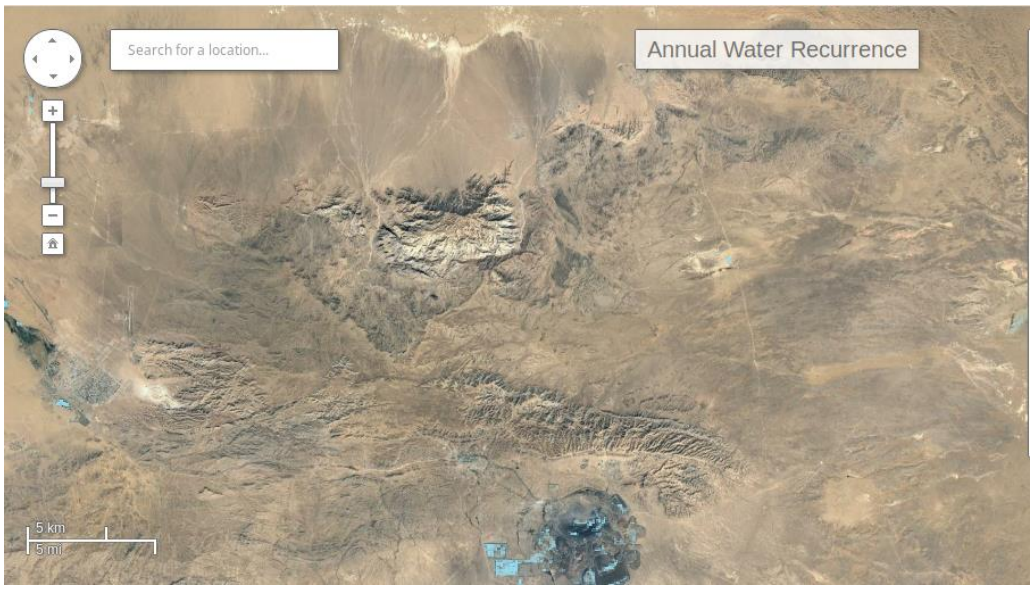




Annual Water Reccurence



Annual Water Recurrence (1984-2019) ON